

8/PRTS

10069750 10/069750

JC18 Rec'd PGT/PTO 22 FEB 2002

8513-225 (SGG-1617-US)

**IMPLANTABLE LEFT VENTRICULAR ASSIST DEVICE WITH**  
**CYLINDRICAL CAM**

**DESCRIPTION**

5 **TECHNICAL FIELD**

10 The present invention relates to a ventricular assist device which is implanted for a patient who suffers from a heart disease in order to assist the patient's heart function, and more particularly, to an implantable left ventricular assist device using a cylindrical cam which is produced in a compact and module form and implanted in a patient who suffers from an acute cardiac insufficiency, to thereby enable oxygen to be supplied smoothly toward the heart of the patient and reconstruct a declined function of the heart.

15 **BACKGROUND ART**

20 In general, as eating habits of people are modernized and westernized, fat and high protein food is excessively taken. Also, a drinking amount increases and a smoking ratio rises up. At the same time, people are exposed to take polluted air due to an atmosphere pollution. Accordingly, the heart disease occurs much in the modernizers under the circumstances. In the case that the function of the heart is not performed well due to the heart disease, a device replacing the function of the heart is used to assist the heart function. As an existing heart assist device, a large heart assist device is provided and used outside of the body of the patient. Accordingly, it is burdensome to use the large heart assist device and inconvenient to carry it, which limits the behavior of the patient. To overcome this problem, a ventricular assist device  
25 which becomes compact to a somewhat degree so as to be explanted to the body of a patient has been developed. However, this explantable ventricular assist device cannot solve inconvenience

5

## **DISCLOSURE OF INVENTION**

10

15

20

25

### **BRIEF DESCRIPTION OF DRAWINGS**

5           The above object and other advantages of the present invention will become more apparent by describing the preferred embodiment thereof in more detail with reference to the accompanying drawings in which:

FIG. 1 is an exploded perspective view schematically shown an implantable left ventricular assist device using a cylindrical cam according to the present invention;

10           FIG. 2 is an assembled sectional view showing the implantable left ventricular assist device using a cylindrical cam according to the present invention shown in FIG. 1;

FIG. 3 is an exploded perspective view showing an actuator and a pusher plate in the present device;

15           FIG. 4 is an assembled perspective view showing the actuator and the pusher plate in the present device shown in FIG. 3;

FIG. 5 is a perspective view showing the state where a planetary gear and a support plate are combined with each other;

FIG. 6A is an exploded perspective view of a minor axis and a cylindrical cam in the present device;

20           FIGs. 6B and 6C are sectional views showing the state where the minor axis and the cylindrical cam are combined with each other; and

FIG. 7 is a partial sectional view showing essential elements in order to explain an operation between the minor axis and the cylindrical cam and a relational operation of a pusher plate in the present device.

# **BEST MODE FOR CARRYING OUT THE INVENTION**

A preferred embodiment of the present invention will be described with reference to the accompanying drawings.

FIG. 1 is an exploded perspective view schematically shown an implantable left ventricular assist device using a cylindrical cam according to the present invention. FIG. 2 is an assembled sectional view of FIG. 1.

The implantable left ventricular assist device includes an actuator 100 for generating a driving force enabling the blood to flow, a pusher plate 200 for transferring the driving force generated from the actuator 100, and a blood sac 300 which is contracted and expanded due to the periodical compression and self-restoration by the pusher plate 200, to thereby flow the blood in and out in correspondence to the ventricle of a natural heart. In addition, the implantable left ventricular assist device includes a chamber 400 for accommodating the actuator 100, the pusher plate 200 and the blood sac 300, combining the same physically, maintaining a predetermined shape, and playing a role of a structural assembly in the body of a patient. The chamber 400 includes a front chamber 410 for accommodating and protecting the blood sac 300 and the pusher plate 200, and a rear chamber 420 for accommodating and protecting the actuator 100.

The actuator 100 converts the torque of a motor 110 installed therein into a linearly driving force to thereby make the pusher plate 200 move back and forth, of which the structure and principle will be described in more detail with reference to FIGs. 3 and 4. In the pusher plate 200 moving back and forth by the actuator 100, a pusher face 210 corresponding to the blood sac 300 forms a substantially flat circular plate shape, on the center of which an engagement hole 220 combined with the movable part of the actuator 100 is perforated. The blood sac 300 is made of an elastic material and is compressed and self-restored by means of

a linearly reciprocating motion of the pusher plate 200 to be contracted and relaxed like the heart. For this reason, the blood sac 300 makes the blood flow in during relax, and flow out during contract, to supply the blood to the necessary portions of the human body.

The actuator 100 includes constructional elements such as a motor 110, a major axis 130, a planetary gear body 140, a minor axis 150, a cylindrical cam 160 and a guiding axle 170, and a case 120 and a rear cover 122 in which the constructional elements are accommodated and fixed. The actuator 100 is accommodated and fixed in the rear chamber 420. The motor 110 is mounted and fixed inside the case 120. A stator 111 of the motor 110 is fixed to the case 120. A rotor 112 is situated adjacent to the stator 111. The rotor 112 is connected with the major axis 130. The major axis 130 is formed of a thin vessel shape. The rear side of the major axis is protruded with a small diameter to form a major axis gear 131. The planetary gear 141 is threadedly engaged with the major axis gear 131 to receive a torque. The planetary gear 141 is fixed on the support plate 142, in which the planetary gear 141 turns round on its axis and revolves the center of the support plate 142. Thus, the support plate 142 rotates on its axial center finally. As described above, the planetary gear 141 and the support plate 142 rotating and revolving form a planetary gear assembly 140. Conclusively, the torque of the motor 110 is reduced through the planetary gear assembly 140 engaged with the major axis gear 131 and the reduced torque is output. For this purpose, a ring gear 124 is fixed inside the case 120 which closely contacts the planetary gear 141, and the planetary gear 141 moves along the ring gear 124 while revolving the ring gear 124. The ring gear 124 closely contacts the rear cover 122 and fixed thereto, in which an annular support circular plate 126 is disposed between the ring gear 124 and the motor 110, in order to divide the ring gear 124 and the motor 110, and attach and fix the ring gear 124 closely to the rear cover 122.

The detailed description with respect to the planetary gear assembly 140 will be given with reference to FIG. 5.

A cross-shaped fixing hole 143 is formed on the center of the support plate 142 in the planetary gear assembly 140. A fixing portion 151 of the minor axis 150 is inserted and fixed into the fixing hole 143. Thus, the minor axis 150 rotates according to the torque of the support plate 142. The minor axis 150 includes a small vessel-shaped fixing portion 151 fixed in the center of the planetary gear assembly 140 and a cylindrical portion 154 forming a large cylinder from the fixing portion 151, in which roller fixing holes 152 are symmetrically formed on predetermined positions and rollers 153 are mounted. A cylindrical cam 160 is inserted inside the cylindrical portion 154, cam grooves 161 are formed on the outer circumferential surface of the inserted cylindrical cam 160, and then a predetermined portion of the roller 153 is inserted. The roller 153 moves along the cam groove 161 according to the rotation of the minor axis 150, and thus the cylindrical cam 160 moves back and forth. In particular, the cam grooves 161 are symmetrically formed on the outer circumferential surface of the cylindrical cam 160. Accordingly, the rollers 153 and the cylindrical cam 160 contact at two places distanced by  $180^\circ$ . As described above, if the cylindrical cam 160 moves back and forth, the pusher plate 200 combined with the cylindrical cam 160 performs a reciprocating motion back and forth. For this, a combination protrude 162 protrudes on the cylindrical cam 160 and inserted into and combined with a combination groove 220 formed in the center of the pusher plate 200.

In particular, a guiding axle 170 is inserted and penetrated into the cylindrical cam 160 in order to guide a linearly reciprocating motion of the cylindrical cam 160. The guiding axle 170 also penetrates the fixing portion 151 of the minor axis 150 which is located in the rear portion of the cylindrical cam 160, and then inserted and fixed into a center fixing hole 122a of the rear cover 122. A guiding piece 172 is disposed between the guiding axle 170 and the cylindrical cam 160, and guides the cylindrical cam 160 to perform a linearly reciprocating

FIG. 5 is a perspective view showing the state where a planetary gear and a support plate are combined with each other.

FIG. 6A is an exploded perspective view of a minor axis and a cylindrical cam in the present device. FIGs. 6B and 6C are sectional views showing the state where the minor axis and the cylindrical cam are combined with each other. Also, FIG. 7 is a partial sectional view showing essential elements in order to explain an operation between the minor axis and the cylindrical cam and a relational operation of a pusher plate in the present device.

7

8513-225 (SGG-1617-US)

cam grooves 161 crossed with each other are formed on the outer circumferential surface of the cylindrical cam 160, in which the rollers 153 are inserted in predetermined positions and then the cylindrical cam 160 and the minor axis 150 are combined with each other. Thus, if the minor axis 150 rotates, the two rollers 153 move on the cam grooves 161 to thereby enable the cylindrical cam 160 to move back and forth. For this purpose, the cam grooves 161 travel around the outer circumferential surface of the cylindrical cam 160 in an X-crossed form, and are formed concavely thereon. Each of the crossed cam grooves forms a sine waveform. Therefore, the rollers 153 move along the cam grooves 161 according to the rotation of the minor axis 150. Accordingly, the cylindrical cam 160 moves back and forth by displacement of the grooves (that is a distance in the axial direction) in the axial direction. A stroke of the cylindrical cam 160 is determined according to the distance in the axial direction of the cam grooves 161.

A combining protrude 162 is formed in the cylindrical cam 160, in order to combine the cylindrical cam 160 with the pusher plate 200 and move the pusher plate 200 back and forth according to the linearly reciprocating motion of the cylindrical cam 160, and a combining groove 220 is formed in the center of the pusher plate 200 corresponding to the cylindrical cam 160, so that the combining protrude 162 and the combining groove 220 are fixedly combined with each other. Also, an axial tubular hole 164 is formed inside the cylindrical cam 160, and the guiding axle 170 is inserted at predetermined positions, in order to guide a linear motion of the cylindrical cam 160 safely. The guiding axle 170 penetrates the minor axis 150 and then is fixed to the center fixing hole 122a of the rear cover 122. The cross-shaped fixing hole 122a is perforated in the center portion of the rear cover 122 of a circular plate type, and a cross-shape mount 170a is formed in the post end of the guiding axle 170 corresponding to the center fixing hole 122a. Also, four guiding protrudes 170b are formed along the axial line of the guiding axle 170. The guiding piece 172 is inserted into the guiding axle 170, and inserted and fixed inside the cylindrical cam 160. The guiding piece



172 is guided linearly since guiding grooves 172a is formed in correspondence to guiding protrude 170b in the guiding axle 170. By doing so, the cylindrical cam 160 in which the guiding piece 172 is fixed is accurately and safely guided on the guiding axle 170 to thereby perform a linear motion.

Now, the operational principle of the left ventricular assist device according to the present invention will be described in detail with reference to the accompanying drawings.

If the present device is implanted in the human body and powered on, the motor 110 in the actuator 100 is driven. Then, the major axis 130 rotates in which the rotor 112 of the motor 110 is fixed. Accordingly, the planetary gears 141 threadedly engaged with the major axis gear 131 rotate and move along the ring gear 124 in the case 120. Then, the support plate 142 rotates in which the planetary gears 141 are fixed. The rotational velocity of the major axis 130 is reduced and the reduced velocity is output to the minor axis 150 fixed to the center of the support plate 142. Thus, the minor axis 150 rotates and the rollers 153 fixed to the minor axis 150 move along the cam groove 161 of the cylindrical cam 160 according to the rotation of the minor axis 150, to thereby perform a reciprocating motion back and forth. Here, the cylindrical cam 160 is linearly guided along the guiding axle 170 by the guiding piece 172 and performs a linearly reciprocating motion stably. Then, the pusher plate 200 fixed to the cylindrical cam 160 performs a reciprocating motion to contract or expand the blood sac 300 and to accordingly take the blood in and out to be supplied to a necessary portion of the human body.

### **INDUSTRIAL APPLICABILITY**

As described above, the implantable left ventricular assist device using a cylindrical cam according to the present invention is produced in a compact and module form, and safely and simply implanted in a patient who suffers from an acute cardiac insufficiency, to thereby

8513-225 (SGG-1617-US)

assist a reduced blood amount of aorta, increase the blood amount of aorta and enable oxygen to be supplied smoothly toward the heart of the patient and reconstruct the declined function of the heart. Thus, the present invention has an effect of expediting a recovery of the lowered heart function.